NASA approaches to preventing and mitigating human error

- Space
  - intense mission-specific training
  - close monitoring by support personnel
- Aviation
  - *human-centered design*
  - initial design: human factors principles
  - design revisions: ASRS

Aviation Error and Technological Change

- Early aircraft: controls

  Example: reversed flight surface controls

- By 1950s: instruments

  Example: altimeter design

- By 1980s: automation-related procedures

  Example: mode confusion in vertical navigation

Example: Automated Teller Machine

Problem: users prone to error in retrieving card

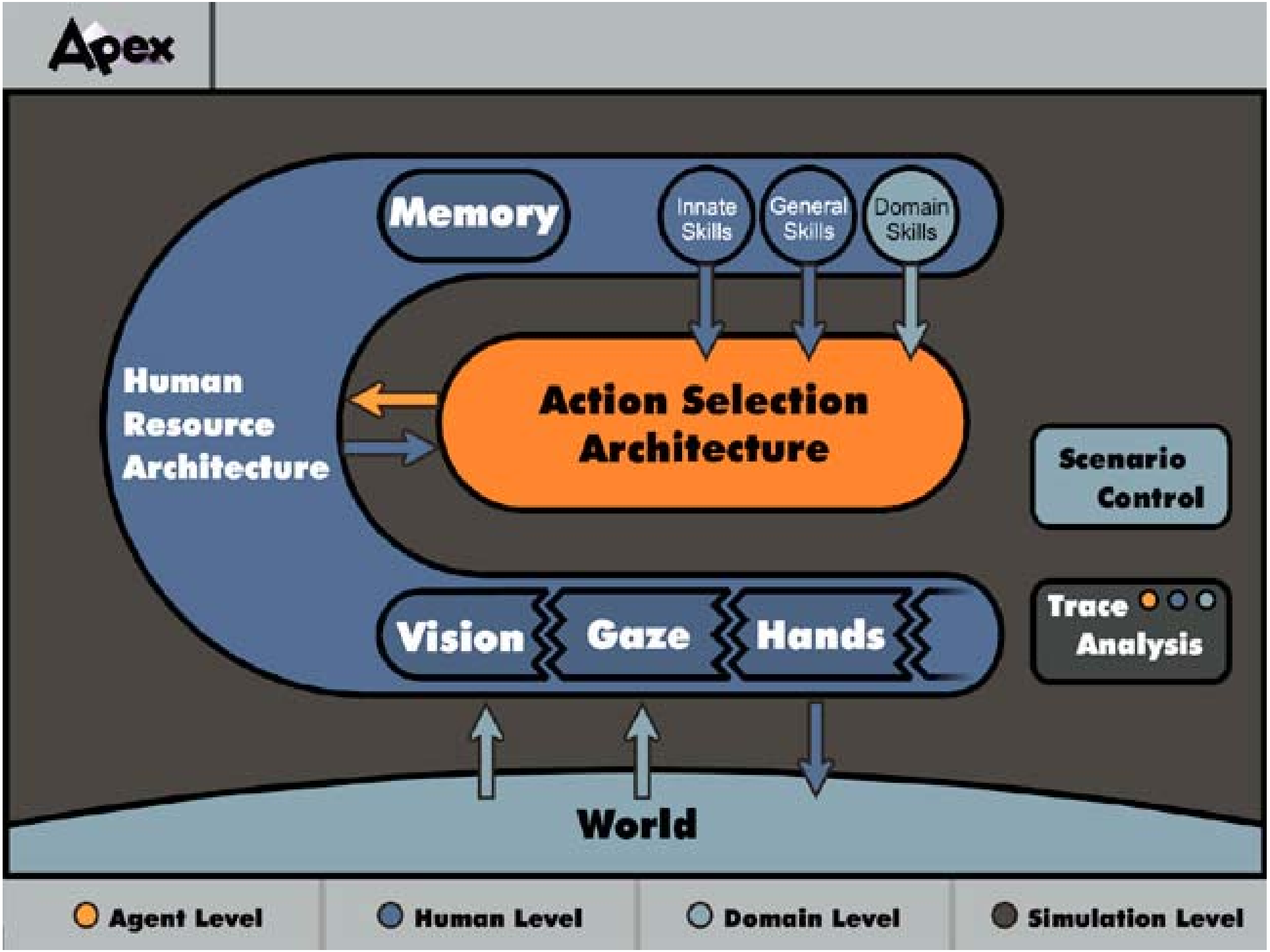
- Costly
- Preventable
- Predictable
- *…but easily overlooked*

Predicting Usability Problems

Strategy: Automated Cognitive Walkthrough

Standard cognitive walkthrough: designer verbally steps through the SOPs for a new device, at each step asking a set of questions intended to identify overlooked usability problems.

Example procedure	Example questions
1. approach ATM	controls reachable?
2. insert card	wrong controls bumpable?
3. select “withdraw”	awkward motions required?
4. specify amount	instructions legible?
5. collect money	options apparent?
6. collect card	next step prompted?
7. collect receipt	next step after main goal done?
	Etc...


Apex
Memory
Innate Skills
General Skills
Domain Skills
Human Resource Architecture
Action Selection Architecture
Scenario Control
Trace
Analysis
Vision
Gaze
Hands
World
Agent Level
Human Level
Domain Level
Simulation Level

Generating Procedural Behavior

Procedure Description Language

PDL Example

```
(procedure
  (index (insert-ATM-card))
  (profile (right-hand (20 seconds)))
  (step s1 (grasp card))
  (step s2 (find-loc card-slot => ?loc))
  (step s3 (move right-hand ?loc)
    (waitfor (holding card) (known ?loc)))
  (step s4 (orient-then-push card card-slot)
    (waitfor (at hand ?loc)))
  (step s4 (terminate) (waitfor (inserted card)))
  (step aux1 (restart ?self)
    (waitfor (resumed ?self))))
```

Language Features

- Step Abstraction
- Method Selection

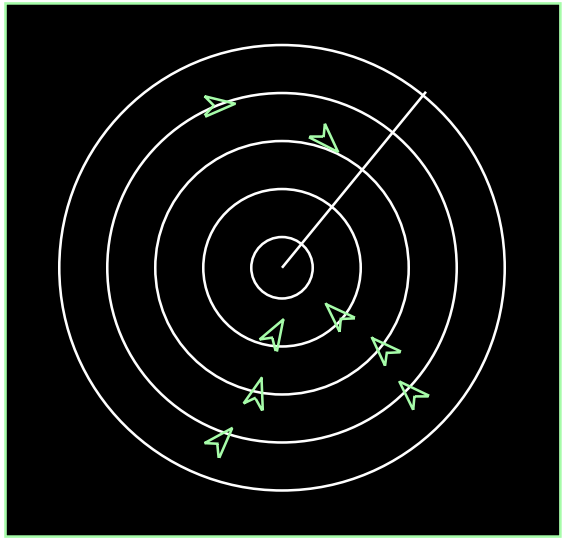
- Interactive Behavior
- Concurrency Control
- Dynamic Prioritization
- Interruption Management
- Periodicity Management
- Expectation Monitoring

Predicting Design-Facilitated Operator Error

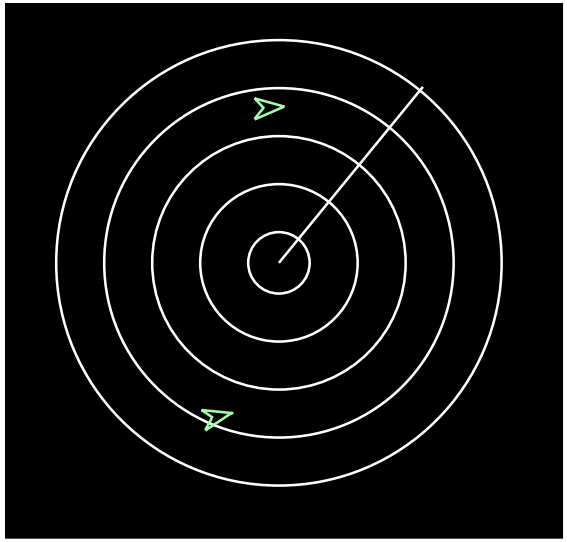
Cognitive biases cause predictable forms of error to arise in predictable circumstances. Such errors occur when: factors that promote bias are present, factors that suppress bias are absent.

Frequency bias: do what is usually done
Recency bias: do what was done last time
Confirmation bias: do what accords with expectations
Innate biases: illusions, visual dominance, completion, satisficing,...

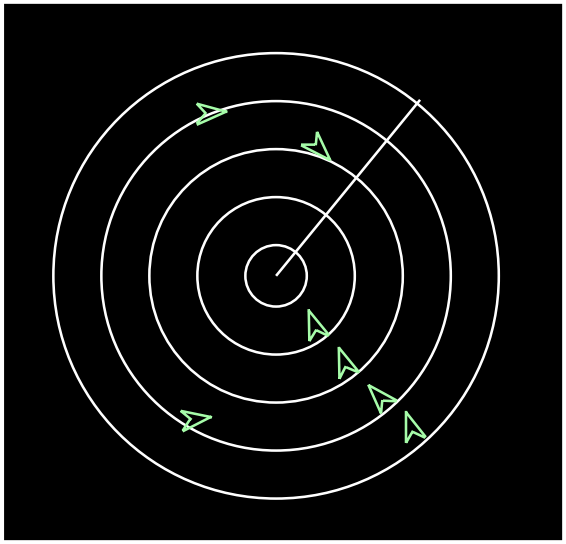
Bias promoting factors: time pressure, high subjective workload
Bias suppressing factors: recent perceptual or cognitive events (e.g. self-remindings) indicating inappropriateness of bias



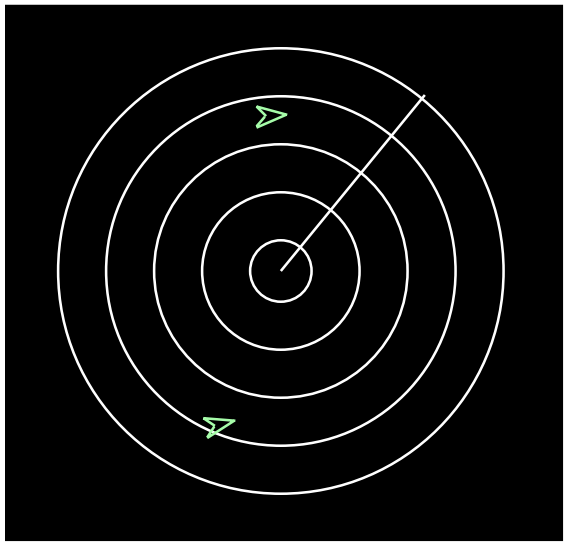
(a) Normal workload: Both runways open



(b) Low workload: Both runways open



(c) Normal workload; Left runway closed



(d) Low workload: Left runway closed